



Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at <http://about.jstor.org/participate-jstor/individuals/early-journal-content>.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

EXPERIMENTS IN BREEDING AS A MEANS OF DETERMINING SOME RELATIONSHIPS AMONG CYCLOPS.

ESTHER F. BYRNES, PH.D.

Two of the largest as well as the most common forms of *Cyclops* are *Cyclops signatus*, var. *coronatus* (*C. fuscus* Jurine) and *Cyclops signatus* var. *tenuicornis*¹ (*C. albidus* Jurine).

Herrick, in his key to the *Cyclops* ("Copepoda, Cladocera and Ostracoda of Minnesota") says of these two forms: "Of the identity of the two varieties which have so long been recognized as distinct species (*C. tenuicornis* and *C. coronatus*) the writer has little doubt. The developmental history has been traced sufficiently to settle this point."

C. tenuicornis and *C. coronatus* are easily distinguishable by the naked eye when adult, and on closer observation they are found to possess several different and very constant characteristics.

C. tenuicornis is generally smaller than *C. coronatus*; the chitin is less deeply pigmented and less hairy; the second segment of the antennule is relatively longer than the corresponding segment in *C. coronatus* as is also the basal joint of the fifth foot.

C. coronatus is larger than *C. tenuicornis*; the chitin is more strongly colored and more hairy; the second joint of the four-jointed antennule is always relatively short as is also the basal joint of the fifth foot. When adult, the female carries her dark egg-masses closely applied to the abdomen. In *C. tenuicornis* the egg-masses are divaricate.

I have attempted to decide the question of any possible identity of these two forms by studies in inheritance.

¹*C. signatus annulicornis* seems to be synonymous with *C. signatus tenuicornis*. Fig. 2, Plate XXXIII., Copepoda, Cladocera and Ostracoda of Minnesota, shows the fourth swimming foot of *C. tenuicornis* with two well-formed setae on the inner margin of the distal segment of the inner ramus. The margins themselves are also strongly hairy. These characteristics are constant in all stages of *C. signatus*, var. *coronatus*, but I have not noted them in *C. tenuicornis* (*annulicornis*).

During the study of the metamorphosis of Cyclops, which is about to be published, I have had the opportunity of observing many details of structure throughout their entire history and have been able to compare these details in one Cyclops with corresponding details in another form.

Two of the forms used in the study of the metamorphosis were *C. signatus*, var. *tenuicornis* and *C. signatus* var. *coronatus*. In *C. tenuicornis* the armature of the distal segment of the inner ramus of the fourth swimming feet is very characteristic. The inner margin of this segment carries two setæ, the more distal of which is extremely small or may even be wholly wanting in which case the site of the seta is marked by a notch in the chitin.

In *C. coronatus* this distal seta is fully developed agreeing in size with all the other setæ in the armature.

While the fourth swimming feet are among the later structures to develop during the metamorphosis, they may be said to undergo four stages in development. During the first stage they are too immature to even suggest their later characteristics. During the second stage the appendages are well formed though only one-jointed; Nevertheless, the terminal armature is present and the setæ on the inner margins of the inner ramus already show their adult characteristics. In the young of *C. signatus* var. *tenuicornis* the distal seta is reduced as in the parent form from which the young is derived. When the next molt occurs the foot becomes two-jointed but the distal armature of the distal segments remains unchanged. After the next molt the appendages become three-jointed as in the adult. Still the distal armature is unchanged and though the Cyclops molts again before acquiring its adult condition no further changes occur in the armature of the swimming feet. New setæ and spines may be added as new segments are formed but each seta retains its original characteristic throughout the metamorphosis.

These studies were made on the broods of females that were isolated while they were carrying their appended egg-masses.

Each female was transferred to a separate aquarium—usually to a small *petri* dish. The water was carefully filtered and microscopic algae were added after careful examination under the microscope showed them to be entirely free from any forms that might contaminate the results of the experiments.

The best results in rearing the young were obtained when the water used in the aquaria was the filtered water from the pond in which the cyclops had been collected. After having set up aquaria with water from various sources, this method was relied on as the one which insured least loss of time through high mortality.

EXPLANATION OF PLATES.

Plate I. shows the inner ramus of the fourth swimming foot of an adult female, *C. signatus* var. *tenuicornis* and the corresponding ramus in each of her seven young. The rami are unsegmented and the armature is incomplete, but the distal seta presents its adult characteristics. In four of the sister forms the seta is present but minute. In three of the young it is altogether wanting though its position is indicated by a notch in the chitin.

Fig. 10 of Plate I. shows the inner ramus of another adult female with the small seta. Figs. 11 and 12 show the corresponding rami in two of her brood. At the time the studies were made the remaining young of this set had not reached the stage in which the fourth foot develops.

Plate II. shows the young of a brood in which some young are in the sixth stage, *i. e.*, with nine antennal segments, some in the seventh stage with ten antennal segments and all the rami two-jointed, while still others are in the eighth stage of the metamorphosis having three joints in the rami of the swimming feet. All of the individuals of all of the successive stages show the seta in question to be strikingly reduced.

We are evidently dealing here with a constant character which appears in a relatively early stage of a complicated metamorphosis and retains its peculiarity in all subsequent stages and even remains as one of the recognition features of the adult.

Similar experiments were made in rearing the young of *C. signatus* var. *coronatus* in which all of the setæ attain a marked development.

Plate III. shows the inner ramus of the fourth swimming foot of an adult female *C. signatus* var. *coronatus*. The distal seta is large and well developed. The young are like the female parent in their armature. Moreover, the hairiness of this Cyclops is not an indication of age, but an inherited character for the

marginal hairs are strongly developed when the foot first appears, long before these appendages are perfectly developed and before the metamorphosis is complete.

The constancy with which the individual characteristics occur throughout the successive stages of a complicated metamorphosis in both of these Cyclops would seem to indicate that the two forms are not at all identical as Herrick supposed, but distinctly different.

Indeed the reappearance of these same peculiarities generation after generation shows that we are dealing with phenomena of inheritance that have become fully established and not with variations, for the correlated characteristics have become so fixed in *C. signatus* var. *tenuicornis* (*annulicornis*) and *C. signatus* var. *coronatus* that each breeds true to its own type.

EXPLANATION OF PLATE I.

Cyclops signatus var. *tenuicornis*. (*Cyclops signatus* var. *annulicornis*; *C. albidus* Jurine.)

FIG. 1. The inner ramus of the fourth swimming foot of an adult female, showing the small distal seta.

FIG. 2. The fifth foot of an adult female, showing the characteristic basal joint of the variety *C. signatus tenuicornis*.

FIGS. 3, 4, 5 and 6. The fourth swimming feet of young in the sixth stage of the metamorphosis, showing the characteristic small distal seta.

FIGS. 7, 8 and 9. The fourth swimming feet of young *C. tenuicornis*, sister forms of 3, 4, 5 and 6. The distal seta is wholly wanting. The location of the seta is indicated by a notch in the chitin.

FIG. 10. The inner ramus of the fourth swimming foot of an adult female.

FIGS. 11 and 12. Two young of Fig. 10. The sixth stage of the metamorphosis is shown in Fig. 11. Fig. 12 shows the fourth foot in the seventh stage.

The adult female, Fig. 1, was isolated July 28. The young of this female (Figs. 3 to 9 inclusive) were studied August 10. The sixth stage of the metamorphosis was, therefore, reached inside of two weeks.



EXPLANATION OF PLATE II.

Cyclops signatus var. *tenuicornis*. (*Cyclops signatus* var. *annulicornis*; *C. albidus* Jurine.)

FIG. 1. The inner ramus of the fourth swimming foot of an adult female, showing the small distal seta on the inner margin of the distal segment.

FIGS. 2 and 3. The fourth swimming feet of young *C. tenuicornis* in the sixth stage of the metamorphosis. The ramus is unsegmented. The antennæ are nine-jointed.

FIGS. 4 and 5. The fourth swimming feet of a young *C. tenuicornis* (young of Fig. 1) in the seventh stage of the metamorphosis. The rami are two-jointed and the antennæ *nine*-jointed and *ten*-jointed, respectively.

FIG. 6. The fourth swimming foot of *C. tenuicornis* (young of Fig. 1) in the eighth stage of the metamorphosis when all the rami are three-jointed. The antennæ are *twelve*-jointed.

All the young of Plate II. are sister forms from the same brood. Some are more advanced in development than others, but they are all the same age.

Two-jointed rami are usually correlated with *ten*-jointed antennæ; *three*-jointed rami are usually correlated with *eleven*-jointed antennæ or with *seventeen*-jointed antennæ as in the adult.



E. F. BYRNES.

EXPLANATION OF PLATE III.

Cyclops signatus var. *coronatus*. (*Cyclops fuscus* Jurine.)

FIG. 1. The terminal segment of the inner ramus of the fourth swimming foot of an adult female showing the characteristically large distal seta on the inner margin.

FIGS. 2, 3, 4 and 5. The fourth swimming feet of young cyclops in the sixth stage of the metamorphosis, showing the distal seta of the young like the distal seta of the parent.

